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Impact of a Water Intervention on Sugar-Sweetened Beverage Intake Substitution by Water: A Clinical Trial in Overweight and Obese Mexican Women

Sonia Hernández-Cordero[a] Barry M. Popkin[b]

[a]Center of Research in Nutrition and Health, National Institute of Public Health, Mexico City, Mexico;
[b]Carolina Population Center, University of North Carolina at Chapel Hill, Chapel Hill, N.C., USA

Key Words
Water · Sugar-sweetened beverages · Interventions

Abstract
Background/Aims: Intense marketing for sugar-sweetened beverages (SSB) along with the human innate preference for sweet taste contributes to the increase in consumption of SSB. It is important to understand the intricacies of dietary intake and global changes to the food supply to understand the complexities facing any intervention promoting water intake. We describe challenges to promote and achieve an increase in water intake and present key findings from a clinical trial examining the effects of substituting water for SSB on triglyceride levels, weight and other cardiometabolic factors in overweight/obese Mexican women. ***Methods:*** A randomized trial was conducted in Cuernavaca, Mexico selecting overweight/obese (BMI ≥25 and <39 kg/m^2) women (18–45 years old), reporting an intake of SSB of at least 250 kcal/day. Women were randomly allocated to the water and education provision (WEP) group (n = 120) or to the education provision (EP) group (n = 120). Repeated 24 h dietary recall questionnaires, anthropometry, and fasting blood levels were collected at baseline and 3, 6, and 9 months following the intervention. ***Results:*** There was no effect of the intervention on triglyceride concentration or on any of the studied outcomes. Post-hoc analyses according to weight at baseline show that triglyceride concentration decreased in obese women. Prevalence of metabolic syndrome after the intervention was lower in obese women from the WEP group. ***Conclusion:*** Water intake was increased but insufficient to achieve complete substitution of SSB, without effects on triglyceride concentration. Post-hoc analyses suggested that interventions lowered triglyceride concentration. Further studies are needed.

Introduction

Evidence shows that sugar-sweetened beverages (SSB) are the largest source of added sugar in most regions of the world. Its consumption is linked with long-term weight gain, risk of type 2 diabetes, metabolic syndrome and cardiovascular disease [1–3]. Evidence, albeit limited, shows that water intake – when replacing SSB, juice and milk – is linked with reduced energy intake [4]. Intense marketing for SSB along with the innate human preference for sweet taste[5, 6] are some of the factors that contribute to the increase in SSB consumption in most countries [7–9]. This report describes the challenges that exist to promote and achieve an increase in water intake

Sonia Hernández-Cordero
Center of Research in Nutrition and Health, National Institute of Public Health
Séptima Cerrada de Fray Pedro de Gante N. 50
Col. Sección XVI, CP 14080, México City (Mexico)
E-Mail cordero@insp.mx

as well as elucidates some key findings of a clinical trial in overweight and obese Mexican women aimed at examining the effect of substituting SSB with water on an array of cardiometabolic factors.

Challenges to Promote and Achieve an Increase in Water Intake

Throughout history, sweetness preference was essential for the survival and evolution for human kind [10]. As the modern manufacturing and food distribution systems and consumer packaged goods (CPG) have evolved along with modern marketing and global subsidies of sugar [11], modern beverage companies have used the preferences of sweetness to create inexpensive beverage alternatives to water and to increase intake of high-caloric sweetened beverages and foods. More recently, promotions of products have been expanded to cover nonnutritive sweetened foods and beverages [12]. In addition, fresh-food markets are disappearing, being replaced by convenience stores and supermarkets in low- and middle-income countries, resulting in processed, packaged foods/beverages rapidly reaching the entire population [13]. In Mexico, 53% of kilocalories per capita and 30% of calories in China come from processed or packaged foods/beverages [14]. In this context, water intake in its natural form is displaced by less healthful options. Thus, when retailers and the CPG sectors expanded globally, dietary worldwide patterns shifted. Over the past decades, there has been an increase in the intake of SSB worldwide. Global SSB intake has grown rapidly as has sugar from processed foods [15, 16]. In Mexico, consumption of caloric beverages doubled from 1999–2006 and by the year 2012, SSB were among the most consumed beverages [9, 17].

It is important to understand the complexity of the dietary intake and global changes in the food supply to understand the complexities facing any intervention to promote water intake among adults and adolescents. The resultant beverage consumption patterns have increasingly replaced water with sweetened and/or caffeinated beverages. Current research is attempting to develop methods to promote water intake. An increasing number of studies involving children show that limited periods of intense interventions can replace other beverages. The first large-scale study was done in German schools, showing that replacing vending machines and beverage choices with filtered water fountains plus water education, reduced risk of overweight by 31% [18].

To date, evidence shows that the best option for the successful promotion of water intake is to improving drinking water access along with health education about the importance of drinking more water (and decreasing SSB) and targeting early stages of life (children) or high-risk populations (i.e., overweight and obese individuals) [19–21]. As far as the knowledge of the authors go, no similar research has been conducted successfully with adults with a sole focus on water. While most weight-control interventions promote water use, few evaluate the impact on water use aside from one weight control randomized controlled trial that focused on provision of water or diet beverages [22].

Results of a Randomized Trial in Overweight and Obese Mexican Women

We conducted a randomized trial in Mexico, a country with one of the highest rates of consumption of SSB globally [9] and with 73% of women being overweight and obese [23]. The methods and results were published elsewhere [24, 25]. Briefly, the trial was conducted in Cuernavaca, México, examining the effect of substituting SSB with water on plasma triglycerides (TG) (primary outcome), weight, and other cardiometabolic factors, as well as evaluating how an increase in water intake affects dietary intake quality. We selected overweight/obese (BMI ≥25 and <39 kg/m^2) women (18–45 years old) reporting SSB intake of at least 250 kcal/day. Women were randomly allocated to the water and education provision (WEP) group (n = 120) or the education provision (EP) only group (n = 120). The WEP group received biweekly water deliveries and both groups received equal monthly nutrition counseling. During nutrition counseling, the WEP group sessions included activities to encourage increased water intake, reduced SSB intake, and substitution of water for SSB. Repeated 24 h dietary recall questionnaires, anthropometry, and fasting blood were collected at baseline and at 3, 6, and 9 months following the intervention [24]. Multiple imputations using the Markov-Monte Carlo method were used. Separate mixed-effect models tested each outcome in the intent-to-treat analysis (ITT). Post-hoc analyses were done considering the nutritional status (measured as BMI) at baseline and increase in water intake during the intervention [25].

Results

ITT analyses showed no effect of the intervention on TG concentration or other studied outcomes despite increased reported water intake and reduced SSB intake. Some potential explanations for these results are incomplete replacement of SSB consumption reported by participants, women in the WEP group still had a high consumption (155 kcal ± 4 kcal/day or 418 ml/day), women in the EP group decreased consumption of SSB and a

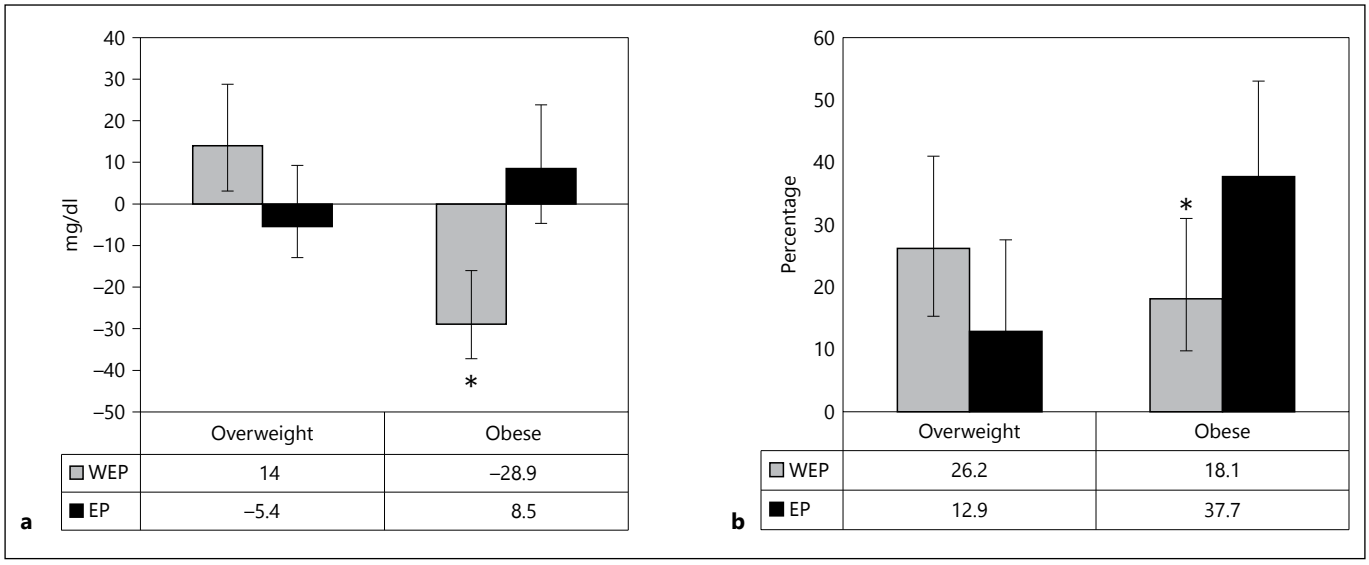

Fig. 1. Effects of the intervention at 9 months based on baseline weight status. (Post-hoc analyses) (**a**) Plasma triglyceride change from baseline to 9 months. **b** Prevalence of metabolic syndrome at 9 months. Values presented are mean ± SE for (**a**) and percentages and 95% CI for (**b**). **a** Simple linear regression model of the change in plasma triglycerides from baseline to 9 months on the treatment group (WEP = 1, EP = 0) and BMI at baseline (obese = 1, overweight = 0); Interaction term: Treatment * BMI at baseline; (n = 184). **b** Logistic regression model adjusted by prevalence of MetS at baseline, treatment (WEP = 1, EP = 0), BMI at baseline (obese = 1, overweight = 0), change in physical activity from baseline to 9 months, age at baseline, interaction treatment. * BMI at baseline; (n = 179). * WEP different from EP, $p < 0.05$. EP = Education provision, WEP = water and education provision.

considerable percentage (37%) increased water intake to >1.2 l/day. Finally, women in both groups decreased total energy intake during the study.

In the post hoc analyses, considering that weight status interacted with the treatment (obesity or BMI ≥30 vs overweight or BMI ≥25 and <30) at baseline, we found that TG concentration decreased from baseline to 9 months in the obese WEP group (228.9–67.70 mg/dl; p value for change <0.001) with no change in the EP group (8.50–10.9 mg/dl; p value for change = 0.4). The prevalence of metabolic syndrome at the end of the intervention was significantly lower for obese women in the WEP group (figure 1) [25]. Some potential explanations for these results are a greater physiological response in subjects with greater risk (obese women) and better compliance to the intervention by obese women. In our study, women in the WEP group demonstrated greater water intake and a greater decrease in the consumption of SSB.

Finally, when we considered the increase in water intake during the intervention, we found that women with a greater increase in water intake showed a higher weight loss, adjusting for age, physical activity (in METs/day), energy intake from solids and from SSB. Thus for every additional liter of water intake during the intervention, women lost 0.4 ± 0.1 kg, $p > 0.005$.

Conclusions

The intervention resulted in increased water intake but was insufficient to achieve a complete substitution of SSB. There was no effect on TG concentration or other cardiometabolic outcomes. Secondary analysis suggests that water intervention lowered TG concentration and prevalence of metabolic syndrome among obese women. This represents an important finding considering that, in Mexico, 37.5% of women are obese [23]. In addition, we found that increased water intake was associated with lower carbohydrate intake and greater weight loss. Results of ITT and secondary analyses require further studies.

Disclosure Statement

No authors have consulted with the Danone Research Center, but some have had grants to conduct epidemiological analyses/talk at Brit Nutr Soc on beverage patterns (BP) or partial support for sabbatical research at the University of North Carolina at Chapel Hill (SHC).

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